UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INFLUENCE OF GOLD SILVER PLATING THICKNESS ON PALLADIUM COATED COPPER WIRE ON STITCH BONDING

TEY SOCK CHIEN

MASTER OF SCIENCE
IN MANUFACTURING ENGINEERING

2016

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TEY SOCK CHIEN

A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
in Manufacturing Engineering

Faculty of Manufacturing Engineering

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DECLARATION

I declare that this thesis entitled "Influence of Gold Silver Plating Thickness on Palladium Coated Copper Wire on Stitch Bonding" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

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Date	:	....

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DEDICATION

To my beloved family, lecturers and friends.

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ABSTRACT

Low cost, high reliable and robust semiconductor packages are required in order for semiconductor manufacturer to stay competitive in the industry. This requires a stable manufacturing process that able to maintain high production yield, reduce customer reject and scrap cost. Currently, combination of Ni/Pd/AuAg preplated Cu alloy leadframe and Palladium coated copper (PCC) wire is used in the wire bonding process of semiconductor package due to its robustness package performances. Nevertheless, studies on the influence of plating layer thickness of roughened preplated leadframe to the stitch bonding strength of the PCC wire is still lacking and not well understood. The purpose of the current study is to investigate the effect of thickness of AuAg plating (i.e. the top plating layer) of the preplated leadframe on the PCC stitch wire bonding. Regression and ANOVA analysis showed AuAg plating's thickness of preplated leadframe was the predominant factor on the stitch bonding strength of PCC wire bonding. The bonding force is the second dominant force, followed by the bonding time. However, the DoE results shows AuAg plating thickness has no significant influence (P value >0.05) on the frequency of machine stoppages (i.e. caused by 'no tail' and 'nonstick on lead' failure on PCC wire stitch bond). Stitch pull strength of PCC wire bonding on the preplated leadframe increased from 10.10 gram-force to 11.20 gram-force, when the AuAg plating's thickness increased from 7.0 to 35.2 nm. Cross-sectional view micrographs of all the stitch bond samples showed failure mode at stitch bond heel, implied the mechanical failure caused by stitch pull test, may be initiated by crack located at the mechanical deformed wire regions (i.e. stitch bond heel). Lower deformation on bond heel observed with thicker AuAg thickness. This is verified by stitch bond thickness data that exhibited thicker stitch bond heel thicknesses when stitch bonding was performed on leadframe with larger AuAg thickness. Stitch remains' length increases with larger AuAg thickness because the resulted thicker stitch heels able to withstand higher stitch pull strength, thus elongated further before break up. Thus, both design of experiments and microstructure analysis results supported the stitch pull strength results as function of AuAg plating thickness. Stitch bonding between PCC wire and leadframe was formed through interdiffusion involving Pd species from PCC wire and Au and Ag species from AuAg plating at the bonding interface. Bonded sample with larger AuAg plating thickness exhibited wider interdiffusion zone, thus further strengthened the stitch bond shear strength. This later prevents shear failure at stitch bond interface during stitch pull test. Higher stitch bond strength further strengthens the package reliability. Thus, it enables semiconductor package application extend into automotive industry like power, safety and engine control applications.

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ABSTRAK

Pakej semikonduktor yang berkos rendah, diyakini dan tahan lasak adalah diperlukan agar pengeluar dan pembuat semikonduktor kekal bersaing di dalam industri ini. Process pembuatan yang stabil serta berupaya mengekalkan prestasi pengeluaran yang bermutu tinggi amat diperlukan bagi mengurangkan barangan ditolak pelanggan dan kos sisa. Kini, kombinasi diantara 'leadframe' bersadur Ni/Pd/AuAg dan wayar Cu bersadur Pd (PCC) digunakan di dalam process jalinan antara wayar dan permukaan 'leadframe'. Ini disebabkan prestasi dan keupayaan tahan lasak pakej. Walaubagaimanapun, kajian ke atas kesan ketebalan lapisan saduran bagi 'leadframe' pra-sadur dan permukaan 'leadframe' yang dikasarkan, berserta kekuatan lekatan jalinan wayar PCC masih lagi berkurangan dan tidak difahami sepenuhnya. Tujuan kajian ini ialah menyiasat kesan ketebalan saduran AuAg (lapisan teratas saduran) pada 'leadframe' pra-sadur keatas lekatan jalinan wayar PCC. Keputusan analisis Regresi dan ANOVA menunjukkan ketebalan saduran AuAg bagi 'leadframe' pra-sadur adalah faktor utama kepada kekuatan lekatan jalinan wayar PCC. Daya lekatan adalah faktor dominasi kedua, diikuti dengan masa lekatan. Menurut keputusan DOE yang dijalankan, pengaruh ketebalan saduran AuAg boleh diabaikan dan tidak memudaratkan keatas kekerapan penghentian mesin (i.e disebabkan oleh 'no tail' dan 'nonstick on lead' pada lekatan jalinan wayar PCC). Berdasarkan ujian tarikan keatas lekatan wayar, Kekuatan lekatan jalinan wayar PCC keatas 'leadframe' pra-sadur, meningkat dari 10.10 gram-daya ke 11.20 gram-daya dan berkadar langsung dengan ketebalan lapisan AuAg yang meningkat dari 7.0 nm ke 35.2nm. Pandangan keratan rentas micrograf bagi semua sampel lekatan jahitan menunjukkan mod kegagalan pada tumit. Lapisan AuAg yang tebal memberikan kesan kusyen yang lebih besar terhadap penyahbentukan tumit dawai semasa process ikatan jahitan. Ini disahkan oleh data jahitan ikatan yang menunjukkan tumit bon jahitan yang tebal dengan ketebalan AuAg yang lebih tinggi. Baki ikatan jahitan didapati juga meningkat dengan ketebalan AuAg yang semakin tinggi. Ini adalah kerana ketebalan ikatan jahitan tumit yang tinggi mampu menampung daya tarikan ikatan jahitan yang lebih kuat, menyebabkan tumit ikatan jahitan terus memanjang sebelum putus. Oleh itu, kedua-dua keputusan eksperimen dan analisis mikrostruktur menyokong keputusan kekuatan tarikan ikatan jahitan sebagai fungsi ketebalan saduran AuAg. Ikatan jahitan antara wayar PCC dan 'leadframe' dibentuk melalui interdiffusion yang melibatkan spesies Pd dari wayar PCC dan Au serta Ag spesies dari penyaduran AuAg atas 'leadframe'. Sampel ikatan dengan lapisan AuAg yang lebih tebal mempamerkan lapisan zon interdiffusion yang lebih luas, seterusnya mengukuhkan lagi kekuatan ikatan jahitan serta mencegah kegagalan ricih semasa ujian tarikan ikatan jahitan.Ikatan jahitan yang tinggi dapat mengukuhkan kebolehpercayaan pakej. Oleh itu, pakej semikonduktor dapat dilanjutkan ke industri automotif seperti aplikasi di kawalan kuasa, keselamatan dan bahagian enjin.

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ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my greatest gratitude to my supervisor Dr. Lau Kok Tee from the Faculty of Manufacturing Engineering Universiti Teknikal Malaysia Melaka (UTeM) for his supervision, support and dedication towards the completion of this thesis. Furthermore I would like to express my sincere acknowledgement to Dr. Mohd Edeeorozey Abd Manaf, co-supervisor of this project for his advice and suggestion throughout the research activities. I would like to express my deepest gratitude to management of Infineon Technologies (Advanced Logic) Sdn Bhd for the financial support of the samples preparation throughout this research. Special thanks to Mr. Chong Hai Sin, my industrial supervisor and also my superior Mr Poh Yong Chern for his advice and guidance. Appreciation also given to Ms. Jolene Tan, Mr Norisham, Mr. Lee Wai Hoo, Mr. Lim Kee Guan, Mr. Yong Foo Khong, Ms. Lim Sau Chin, Mr. Siah Beng Eng, Mr. Vincent Yeo and Ms. Tan Yik Yee for the support given in the assembly process and assistance in the lab and analysis works. Special thanks to my beloved family for their moral support in completing this master degree. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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LIST OF ABBREVIATIONS,

SYMBOLS AND NOMENCLATURE

Ag	-	Argentum
Al	-	Aluminium
Ar	-	Argon
Au	-	Aurum
Be	-	Beryllium
BGA	-	Ball grid array
BT	-	Bismaleimide Triazine
CAGR	-	Compound annual growth rate
CN	-	Cyanide
Cr	-	Chromium
CQFP	-	Ceramic quad flat package
CSP	-	Chip scale package
Cu	-	Cuprum
DF	-	Degree of freedom
DIP	-	Dual in line package
DOE	-	Design of experiment
ECU	-	Electronic control unit
EDX	-	Energy dispersion x-ray

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EFO	-	Electric flame off
ENEPIG	-	Electroless nickel electroless palladium immersion gold
FAB	-	Free air ball
FCC	-	Face center cubic
Fe	-	Ferum
FESEM	-	Field emission scanning electron microscope
FIB	-	Focus Ion Beam
FR4	-	Flame retardant 4
GAM	-	Brightness value
g/cm^3	-	gram per centimeter cube
gf	-	gram force
GPS	-	Global positioning satellite
H_2	-	Hydrogen
HEPA	-	High efficiency particulate air
IC	-	Integrated circuits
IMC	-	Intermetallic Compound
I/O	-	Input Output
LCD	-	Liquid crystal display
L/min	-	Litre per minute
Low-k	-	Small dielectric constant
MIS	-	Molded interconnect substrate
MPa	-	Mega pascal
ms	-	milisecond
N_2	-	Nitrogen

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Ni	-	Nickel
Ni-P	-	Nickel Phosphorus
Ni-Pd-Au	-	Nickel Palladium Aurum
Ni-Pd-AuAg	-	Nickel Palladium Aurum Argentum
nm	-	Nanometer
Ohm.m	-	Resistivity, Ohm meter
Pb	-	Lead, Plumbum
PCB	-	Printed circuit board
PCC	-	Palladium coated copper wire
Pd	-	Palladium
PGA	-	Pin grid array
PLCC	-	Plastic leaded chip carriers
ppm	-	Part per million
Ra	-	Average roughness
RMS	-	Root mean square
QFP	-	Quad flat package
QIL	-	Quad in line
RoHS	-	Restriction of the use of certain hazardous substance in electrical and electronic equipment
SIP	-	Single in line
Sn	-	Stannum, Tin
SOIC	-	Small outline integrated circuit
SS	-	Sum of squares
STEM	-	Scanning transmission electron microscopy

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TAB	-	Tape automated bonding
TEM	-	Transmission electron microscopy
TV	-	Television
UV	-	Ultraviolet
vol%	-	Volume percentage
XRF	-	X-ray fluorescence spectroscopy
W	-	Watt
WEEE	-	Waste electrical and electronic equipment.
WLP	-	Wafer level package
W/mK	-	Watt per meter kelvin
wt%	-	Weight percentage
Zn	-	Zinc
^{o}C	-	Degree Celsius
µm	-	micro meter
lb./in.^{2}	-	pound per square inch,

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